भारतीय मानक
Indian Standard

IS 18309 : 2023

भुकृत्रिम — अत्यंत नरम मिट्टी के त्वरित समेकन के लिए पूर्व निर्मित ऊर्ध्वाधर नालियां — विशिष्टि

Geosynthetics — Prefabricated Vertical Drains for Quick Consolidation of Very Soft Plastic Soil — Specification

ICS 59.080.70

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August 2023 Price Group 6

Geosynthetics Sectional Committee, TXD 30

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Geosynthetics Sectional Committee had been approved by the Textiles Division Council.

Prefabricated Vertical Drains (PVDs) are geosynthetic composite drainage material consisting of a polymer core and a geotextile enclosure installed into foundation soils. Prefabricated vertical drains have become important in several projects especially in ports and all other structures to accelerate consolidation of very soft soil for improving the load bearing capacity and settlement potential of the loose or soft soil lying at larger depths.

Consolidation occurs very slowly in saturated, fine-grained soils because the low permeability of these soils impedes the escape of pore water from the voids. Prefabricated vertical drains act as a potential solution for accelerating the consolidation and dissipation of excess pore water pressure within very short span where unpredictable long-term settlement is common problem. The pore water in the soil voids take many years because of slow movement of water to cover the large distance to exit the soil. The purpose of vertical drain system is to reduce the drainage path of the pore water from a low permeable layer to free water surface thereby accelerating the rate of primary consolidation of the process of settlement. This method of ground improvement using prefabricated vertical drain coupled with surcharge or preloading can significantly shorten the period of primary settlement. This static surcharge load causes an increase in pore water pressures in the drains. The excess pore water pressure developed actuates the drainage of the pore water toward the prefabricated vertical drains resulting in the consolidation of the saturated soft deposit.

In the formulation of this standard, due importance has been given to global standards and practices as well as existing standards and practices in India.

This standard will help engineer in selecting prefabricated vertical drains of appropriate quality for specific project requirements. Procurement of the prefabricated vertical drains shall be done as per such requirements and the material shall be selected, comparing the parametric requirement by design and the design value indicated in the manufacture’s data sheets. The contractor shall follow the specifications and installation guidelines provided by engineer or by the prefabricated vertical drain manufacturer.

The composition of the Committee responsible for the formulation of this standard is given in Annex B.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

GEOSYNTHETICS — PREFABRICATED VERTICAL DRAINS FOR QUICK CONSOLIDATION OF VERY SOFT PLASTIC SOIL — SPECIFICATION

1 SCOPE

1.1 This standard specifies material properties and specifications that are required for the use of prefabricated vertical drains for consolidation acceleration applications, ground improvement in regions of saturated and compressible soil.

1.2 This standard is a specification aid for material purchase and shall not be used as design or construction guideline. Design and construction of vertical drains used for improving the ground is recommended to be carried out separately using IS 15284 (Part 2).

2 REFERENCES

The standards listed in Annex A contain provisions which through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of these standards.

3 DEFINITIONS

3.1 Prefabricated Vertical Drain (PVD) — A geo-composite prefabricated composite material consisting of a channeled polymer inner core covered by nonwoven geotextile filter fabric (*see* Fig. 1). It is installed into foundation soils to achieve 90 percent consolidation of sub-soil within a prescribed time (*see* Fig. 2). The core serves as a longitudinal flow path along the drain length and the geotextile wrapping allows water to pass into the core and limits the intrusion of soil particles into the core area.

PVDs can be installed in either square or triangular pattern. Triangular pattern provides more uniform consolidation between the drains. The relationship of drain influence zone (D) to drain spacing is expressed by:

For square pattern	D = 1.13 S
For triangular pattern	D = 1.05 S

3.2 Ultimate Flow Rate of Core (q_{ult}) — The ultimate flow rate of a prefabricated vertical drain as determined by laboratory test in accordance with IS 17179.

3.3 Consolidation — The geotechnical process by which in-situ saturated soil deposits expel their pore water bringing the soil particles together into a gradually increasing density and shear strength.

4 TYPES OF PREFABRICATED VERTICAL DRAINS

Prefabricated vertical drains shall be of following types based on its application:

a) *Type* I — Prefabricated vertical drain used for installation in ground depth up to 15 meters; and

b) *Type* II — Prefabricated vertical drain used for installation in ground depth greater than 15 meters.

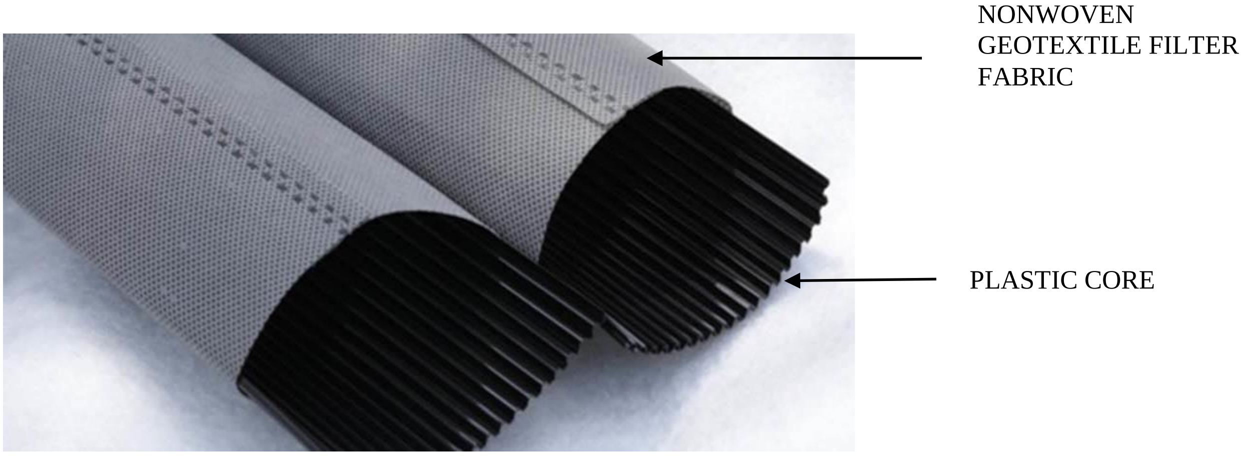

FIG. 1 PREFABRICATED VERTICAL DRAIN

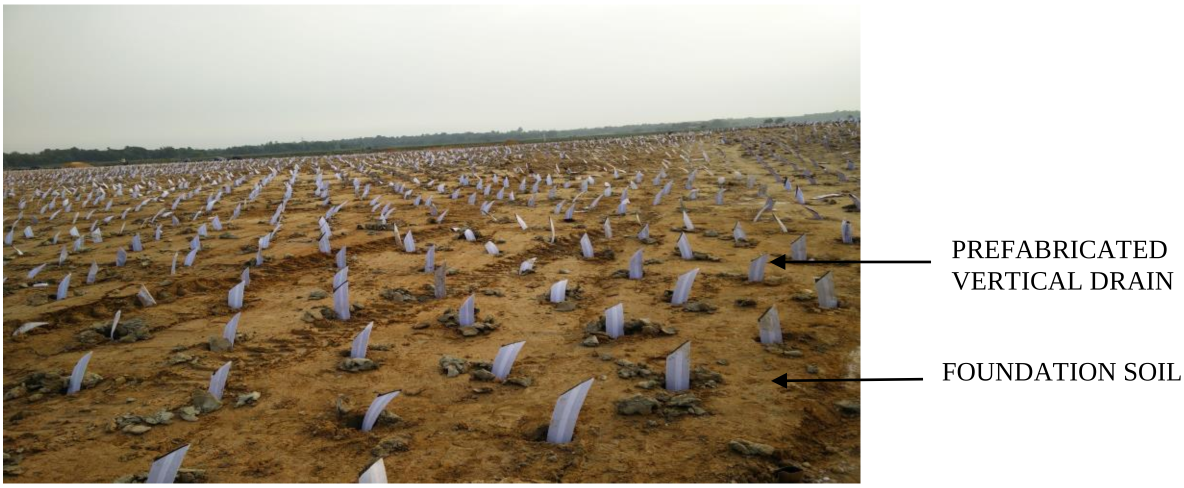

FIG. 2 PREFABRICATED VERTICAL DRAIN INSTALLED INTO FOUNDATION SOILS

5 MATERIALS

5.1 Geosynthetic strip or band drain shall consist of a corrugated inner core wrapped in a nonwoven geotextile. Band drain shall be of width and thickness as specified in the design and shall be a minimum of 100 mm width and 3 mm thickness. The core shall serve as the drainage medium conveying the core water from the soft subsoil to the drainage layer at the top. The core shall be of three-dimensional mesh made of continuous plastic material fabricated to facilitate drainage along the axis of the vertical drain. The filter shall be nonwoven fabric. The filter and the core shall be ultrasonically welded together at edges to produce a fully-integrated product.

5.2 The polypropylene used for manufacture of non-woven filter and inner core shall conform to the requirements specified in IS 667. Prefabricated vertical drain materials (polypropylene) shall be inert to all chemicals naturally found in commonly encountered soils not containing adverse solvents and at ambient temperatures. These shall be resistant to rot and mildew and shall have no tears or defects which adversely affect or alter its physical properties.

5.3 After installation of the vertical drains in the sub soil, a blanket of well-draining granular material compacted to a density of 75 percent to 80 percent of maximum dry density obtained by heavy compaction shall be provided. This granular/sand blanket shall be exposed to atmosphere at its boundaries for dissipation of pore water pressure.

6 REQUIREMENTS FOR PREFABRICATED VERTICAL DRAINS

6.1 Prefabricated vertical drains shall be dimensionally stable and able to retain their geometry under manufacture, transport, and installation.

6.2 Prefabricated vertical drains shall meet requirements as specified in Table 1.

Table 1 Requirements of Prefabricated Vertical Drains

(*Clause* 6.2)

Sl No.	**Characteristic**	**Requirement**		**Method of Test, Ref to**
		Type 1	Type 2	
(1)	(2)	(3)	(4)	(5)
A)	**Overall Drain**			
i)	Discharge capacity			
	a) At 300 kPa, i = 1.0, Straight condition, m^3/s, *Min*	90×10^{-6}	80×10^{-6}	IS 17179
	b) At 300 kPa, i = 1.0, Buckled condition, m^3/s, *Min*	55×10^{-6}	55×10^{-6}	IS 17179
ii)	Tensile strength, kN, *Min*	1.5	2	IS 16635
iii)	Elongation at 1 kN, Percentage, *Max*	5	10	IS 16635
iv)	Elongation at break, Percentage, *Min*	40	40	IS 16635
v)	Thickness, mm, *Min*	4.0	4.0	IS 13162 (Part 3)
vi)	Width, mm	100 ± 3	100 ± 3	IS 1954
vii)	Roll length, m	100 to 200 (Tolerance + 1 m with no negative tolerance)		IS 1954
B)	**Filter**			
i)	Mass per unit area, g/m^2, *Min*	110	120	IS 14716
ii)	Wide width tensile strength (MD), kN/m, *Min*	3	6	IS 16635
iii)	Grab tensile strength (MD), N, *Min*	250	500	IS 1969 (Part 2)
iv)	Grab tensile elongation (MD), Percentage, *Min*	45	45	IS 1969 (Part 2)
v)	Index puncture strength, N, *Min*	100	120	IS 16348
vi)	Trapezoidal tear, N, *Min*	50	150	IS 14293
vii)	Permeability, m/s, *Min*	5×10^{-6}	5×10^{-6}	IS 14324
viii)	Pore size, µ, *Max*	75	75	IS 14294

7 INSTALLATION OF PREFABRICATED VERTICAL DRAINS

7.1 Prefabricated vertical drains are installed using either vibratory or static methods. The drain is enclosed in a tubular steel mandrel of small cross-section area usually 50 mm x 125 mm. A small steel anchor plate is attached to the drain at the bottom of the mandrel. The mandrel is then driven into the soil with an installation rig. The mandrel is extracted when the design depth is reached. The anchor plate retains the drain in the soil. The drain is cut off when the mandrel is fully extracted and the process is repeated for installing prefabricated vertical drains further.

7.2 Appropriate size of mandrel and anchor plate should be used for installation for minimizing soil disturbance.

7.3 The penetration rate should be appropriate to avoid significant bending.

7.4 The verticality should be kept into consideration for successful installation of prefabricated vertical drains.

8 MARKING AND LABELLING

8.1 The prefabricated vertical drain material shall be marked with the following information by attaching the printed labels:

a) Manufacturer’s name, initials or trademark;
b) Identification of the prefabricated vertical drain material;
c) Roll length, m;
d) Lot and batch number;
e) Date of manufacture of prefabricated vertical drain material;
f) The country of origin; and
g) Any other information required by the law in force.

8.2 BIS CERTIFICATION MARKING

The prefabricated vertical drain conforming to the requirements of this standard may be certified as per the conformity assessment schemes under the provisions of the *Bureau of Indian Standards Act*, 2016 and the Rules and Regulations framed thereunder, and the product(s) may be marked with the Standard Mark.

9 PACKING

The prefabricated vertical drain shall be packed as per the contract or order. Each roll shall be protected by wrapping it in a film of minimum thickness of 50 microns to prevent it from the adverse impact of heat and moisture, oil, grease, dirt, dust and other stains.

10 IDENTIFICATION, DELIVERY, STORAGE AND HANDLING

10.1 The prefabricated vertical drain labelling, shipment, storage and handling shall be in accordance with IS 17421.

10.2 During storage, prefabricated vertical drains shall be elevated off the ground and adequately covered to protect from the following:

a) Site construction damage;
b) Excessive precipitation;
c) Extended exposure ultraviolet radiations including sunlight;
d) Aggressive chemicals for example, strong acids and strong bases;
e) Flames, welding sparks or temperatures more than 71 ºC;
f) Excessive mud, wet concrete, epoxy, or other deleterious materials coming in contact with and affixing to the prefabricated vertical drain material; and
g) Any other environmental condition that may damage the physical property values of prefabricated vertical drain.

10.3 Store the prefabricated vertical drain material at temperatures above minus 20 ºC and below 40 ºC.

10.4 Lay the rolled materials flat or vertical on ends.

10.5 Do not drag the rolls but carefully lift them off the ground to be carried manually or by fork lift/cranes with suitable jigs.

10.6 Do not leave the prefabricated vertical drain material directly exposed to sunlight for a period longer than the period recommended by the manufacturer.

10.7 Each prefabricated vertical drain roll shall be wrapped with a material that will protect it from damage due to shipment, water, sunlight and contaminants.

10.8 Keep prefabricated vertical drain dry until installation, and do not store directly on the ground.

11 SAMPLING AND CRITERIA FOR CONFORMITY

11.1 Lot

All prefabricated vertical drain rolls of same material, construction and type dispatched to a buyer against one dispatch note shall constitute a lot.

11.2 Unless otherwise agreed to between the buyer and the seller, the number of prefabricated vertical drain rolls to be selected at random from a lot shall be as given in col (3) of Table 2.

Table 2 Scale of Sampling

(*Clause* 11.2)

Sl No. (1)	No. of PVD Rolls in Lot (2)	Sample Size (3)	Sub-Sample Size (4)	Permissible No. of Defective Rolls (5)
i)	Up to 50	3	2	0
ii)	51 to 150	5	2	0
iii)	151 to 300	8	3	1
iv)	301 to 500	13	5	2
v)	501 and above	20	5	3

11.3 Number of Test Specimens and Criteria for Conformity

Number of test specimens and criteria for conformity shall be as given in Table 3.

Table 3 Number of Test Specimens and Criteria for Conformity

(*Clause* 11.3)

Sl No. (1)	Characteristic (2)	No. of Rolls (3)	Criteria for Conformity (4)
i)	Clause **5.1**, **5.2**, tensile strength, elongation length, width	According to col (3) of Table 4	The defective rolls/pieces do not exceed the corresponding number given in col (5) of Table 4
ii)	All other requirements	According to col (4) of Table 4	All the test specimens shall pass the tests

ANNEX A

(*Clause* 2)

LIST OF REFERRED STANDARDS

IS No.	*Title*
IS 667 : 1981	Methods for identification of textile fibres (*first revision*)
IS 1954 : 1990	Determination of length and width of woven fabrics — Methods (*second revision*)
IS 14293 : 1995	Geotextiles — Method of test for trapezoid tearing strength
IS 14294 : 1995	Geotextiles — Method for determination of apparent opening size by dry sieving technique
IS 14324 : 1995	Geotextiles — Method of tests for determination of water permeability — Permittivity
IS 14716 : 2021	Geosynthetics — Test method for the determination of mass per unit area of geotextiles and geotextile-related products (*first revision*)
IS 15284 (Part 2) : 2004	Design and construction for ground improvement — Guidelines: Part 2 Preconsolidation using vertical drains
IS 16348 : 2015	Geosynthetics — Method of test for index puncture resistance of geomembranes and related products
IS 17421 : 2020	Geosynthetics — Identification on site
IS 1969 (Part 2) : 2018/ISO 13934-2 : 2014	Textiles — Tensile properties of fabrics: Part 2 Determination of maximum force using the grab method (*fourth revision*)
IS 13162 (Part 3) : 2021/ISO 9863-1 : 2016	Geosynthetics — Determination of thickness at specified pressures: Part 3 Single layers (*first revision*)
IS 16635 : 2017/ ISO 10319 : 2005	Geosynthetics — Wide width tensile test
IS 17179 : 2019/ ISO 12958 : 2010	Geotextiles and geotextile related products — Determination of water flow capacity in their plane

ANNEX B

(*Foreword*)

COMMITTEE COMPOSITION

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Organization	*Representative(s)*
The South India Textile Research Association Council, Coimbatore	Dr A. N. Desai **(*Chairperson*)**
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Best Geotechnique Pvt Ltd, Mumbai	Shri Satish Naik
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Ganga Flood Control Commission, Patna	Shri M. K. Srinivas Shri Amitabh Prabhakar (*Alternate*)
Garware Technical Fibers Ltd, Pune	Shri Tirumal Kulkarni Shri Rajendra Ghadge (*Alternate*)
Geosynthetics Testing Services Pvt Ltd, Ahmedabad	Shri Ravikant Sharma
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Kusumgar Corporates, Mumbai	Shri Y. K. Kusumgar Dr M. K. Talukdar (*Alternate*)

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This Indian Standard has been developed from Doc No.: TXD 30 (19403).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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Published by BIS, New Delhi